American

POTATO JOURNAL

Volume 35 *January 1958* *Number 1*

CONTENTS

The influence of environmental factors and pollinating techniques on the success of potato pollination in the greenhouse .....

DARREL R. BIENZ 377

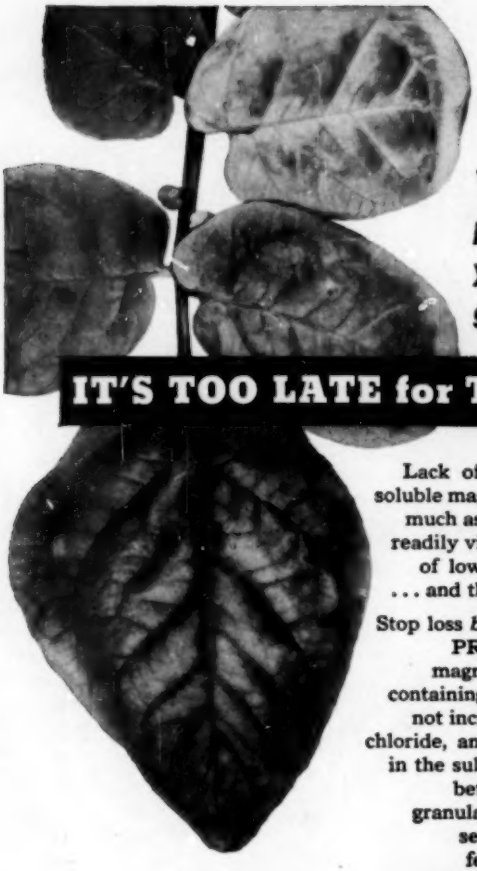
The influence of fertilizer treatments on the yield, grade, and specific gravity of potatoes in eastern Oregon .....

JOHN A. YUNGEN, ALBERT S. HUNTER AND TURNER H. BOND 386

Official Publication of

THE POTATO ASSOCIATION OF AMERICA

NEW BRUNSWICK, NEW JERSEY, U. S. A



When lower potato leaves show yellow between green veins...

IT'S TOO LATE for TOP PROFITS!

Lack of available, fast-acting, water-soluble magnesium lowers potato yields as much as 100 bushels per acre. The first readily visible sign of loss is a yellowing of lower leaves, between green veins ... and then top profits are already lost.

Stop loss *before* it's TOO LATE for TOP PROFITS! Supply water-soluble magnesium with premium fertilizer containing Sul-Po-Mag®, or SPM. It will not increase danger of scab, it's low in chloride, and Sul-Po-Mag supplies potash in the sulphate form for better chipping, better shipping potatoes. SPM is granular to lessen leaching. When you see your dealer, ask for premium fertilizer containing Sul-Po-Mag.

S·P·M PREMIUM

Premium quality fertilizer certified through use of a balanced combination of the water-soluble magnesium and potash obtained from Sul·Po·Mag®

This Seal Guarantees Your Premium Fertilizer Contains

Sul·Po·Mag®

Water-Soluble Sulphate of Potash-Magnesia
($K_2SO_4 \cdot 2MgSO_4$) 22% K_2O – 18% MgO

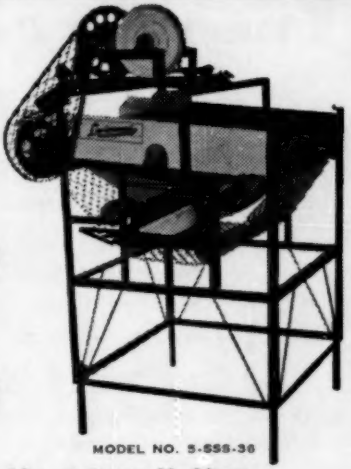
International MINERALS & CHEMICALS

POTASH DIVISION

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

20 NORTH WACKER DRIVE • CHICAGO 6, ILL.

"TOP THE MARKET" with the Right Size Potatoes



MODEL NO. 5-SSS-36

LOCKWOOD

* *A Symbol of Service.*
* *A Sign of Quality.*

Potato Machinery for all needs. Let a Lockwood representative solve your problems.

— *Manufacturing A Complete Line of Potato Machinery* —

LOCKWOOD GRADERS
GERING NEBR.
— OFFICES IN ALL PRINCIPAL POTATO AREAS —

IT PAYS TO BE HIDDEN HUNGER CONSCIOUS

Plants, like people, can suffer from hidden hunger — the period between the time they are in good health and in bad health. This is an insidious time because nothing looks wrong. The plant seems to be healthy — or certainly shows no signs of hunger. And then — almost suddenly, it seems — the plant crosses a point of no return as far as its finest yield and quality are concerned. Outward signs may never show — except in the yield. It's an insidious thing. Hidden Hunger! A problem requiring careful diagnosis and management that is always hunger conscious.

AMERICAN POTASH INSTITUTE, INC.
SERVING AGRICULTURE FOR OVER TWO DECADES

1102 Sixteenth St., N. W. Washington 6, D. C.

Member Companies: American Potash & Chemical Corporation • Duval Sulphur & Potash Company • Potash Company of America • Southwest Potash Corporation • United States Potash Company Division of United States Borax & Chemical Corporation

American Potato Journal

PUBLISHED BY
THE POTATO ASSOCIATION OF AMERICA
NEW BRUNSWICK, N. J.

EXECUTIVE COMMITTEE

J. C. CAMPBELL, *Editor-in-Chief*
WM. H. MARTIN, *Honorary Editor*
E. S. CLARK, *Associate Editor*

Rutgers University, New Brunswick, New Jersey

N. M. PARKS, *President* ..... Department of Agriculture, Ottawa, Canada
W. J. HOOKER, *President-Elect* ..... Michigan State University, East Lansing, Mich.
PAUL J. EASTMAN, *Vice President* ..... Department of Agriculture, Augusta, Maine
ROBERT V. AKELEY, *Secretary* ..... U. S. Department of Agriculture, Beltsville, Md.
JOHN C. CAMPBELL, *Treasurer* ..... Rutgers University, New Brunswick, N. J.
R. W. HOUGAS, *Past President* ..... University of Wisconsin, Madison, Wisconsin
D. S. MACLACHLAN, *Director* ..... Department of Agriculture, Ottawa, Canada
ORRIN C. TURNQUIST, *Director* ..... University of Minnesota, St. Paul, Minn.
E. J. WHEELER, *Director* ..... Michigan State University, East Lansing, Mich.

Price $4.00 per year in North America; $5.00 in other countries.
Not responsible for free replacement of non-delivered or damaged issues after 90 days.

Entered as second class matter at New Brunswick, N. J., March 14, 1942 under Act of March 3, 1879. Accepted for mailing at special rate of postage provided for in section 412, Act of February 28, 1925, authorized on March 14, 1928.

SUSTAINING MEMBERS

STARKS FARMS INC. ..... Route 3, Rhinelander, Wisconsin
BACON BROTHERS ..... 1425 So. Racine Ave., Chicago 8, Illinois
L. L. OLDS SEED CO. ..... Madison, Wisconsin
FRANK L. CLARK, Founder — Clark Seed Farms ..... Richford, New York
RED DOT FOODS, INC. ..... Madison, Wisconsin
ROHM & HAAS COMPANY ..... Philadelphia, Pennsylvania
WISE POTATO CHIP CO. ..... Berwick, Pennsylvania
JOHN BEAN DIVISION, FOOD MACHINERY CORP. ..... Lansing 4, Michigan
S. KENNEDY & SONS, Growers and Shippers of Potatoes and Onions .. Clear Lake, Iowa
OLIN MATHIESON CHEMICAL CORP. ..... Mathieson Bldg., Baltimore 3, Maryland
AMERICAN AGRICULTURAL CHEMICAL CO. ..... Carteret, New Jersey
LOCKWOOD GRADER CORP. ..... Gering, Nebraska
EDWARD H. ANDERSON & CO. ..... 1425 S. Racine Ave., Chicago, Illinois
E. I. DU PONT DE NEMOURS AND CO. (INC.)
Grasselli Chemicals Dept. ..... Wilmington 98, Delaware

THE INFLUENCE OF ENVIRONMENTAL FACTORS AND POLLINATING TECHNIQUES ON THE SUCCESS OF POTATO POLLINATION IN THE GREENHOUSE[1]

DARREL R. BIENZ[2]

INTRODUCTION

Each year thousands of crosses are made by potato breeders in this country. Although many of these are fruitful, crosses between some of the most desirable parental types result in very few or no viable seed. There are many causes of non-fruitfulness in the potato but it has been known for a number of years that environment plays an important role. Not only could the number of crosses producing fruit be increased but also the efficiency of the breeding program could be considerably improved if each potato breeder knew at what stages of flower maturity and at what time of day he might pollinate a flower with a reasonable chance that it would set fruit. He should also know how high the temperature could rise before further pollinating is a waste of time. Definite information concerning these and other problems connected with the effect of environment and pollinating techniques on fruit setting in potatoes is not presently available to most potato breeders.

Regarding the effect on environment on non-fruitfulness of the potato plant, Young (14) pointed out that high temperature and low moisture cause degeneration of embryo-sacs at all stages of flower development. Longley and Clark (11) found that environmental differences during two seasons had little effect on the fertility of some potato varieties but caused considerable variation in others. This variation, they believed, was due to differences in the amount of moisture during the two seasons, more meiotic disturbances occurring during the season of scanty rainfall.

Edmundson (7) found that significantly more viable pollen was produced on plants grown in the greenhouse at Greeley, Colorado, (elevation, 4800 feet) or in the field at Estes Park, Colorado, (elevation, 7500 feet) than was produced on plants of the same variety grown in the field at Greeley. No differences in amount or viability of pollen were found for plants grown at the first two locations. Low temperature and high humidity were found to be the conditions most favorable for the formation of viable pollen in Louisiana by Henderson and LeClerg (9). Clarke (2) observed that about 36 hours were required for fertilization to occur after the stigma had been pollinated. A high temperature during these critical hours, he believed, hastened macrospore degeneration and abscission.

East (6) mentions that pollen appeared to be in the best condition for use in the early morning of the second day of blooming and that it was at this time that the stigma was most receptive. Salaman (12), in describing a procedure for a potato breeding program, says that pollination should

[1]Accepted for publication August 12, 1957.

[2]Paper No. 334, Department of Plant Breeding, Cornell University, Ithaca, N. Y. (Part of a thesis submitted to the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.)

[3]Formerly Graduate Research Assistant, Department of Plant Breeding, Cornell University, and now Assistant Horticulturist, Idaho Agricultural Branch Experiment Station, Aberdeen, Idaho.

take place after the flowers are open. He says that flowers can be pollinated at the time of emasculation (24-48 hours before they open) but that fruit set at this time is poor. Henderson and LeClerg (9) found that flowers pollinated at the time of emasculation failed to set as much fruit as those pollinated 24 hours later. They did note pollen tubes in the styles of the buds pollinated at the time of emasculation and so assumed that the ovules were probably immature when the pollen tubes reached them.

That the position of the flower cluster may effect fruit set was shown by East (6) who found that the flower clusters produced in the center of the plant are more apt to set fruit than are those produced above or below. Amount and intensity of light are also known to influence the number of flowers and berries produced, (4), (5), and (13). Clarke and Lombard (3) report that seed-piece size may affect the number of flowers formed and, consequently, the number of fruit set.

Materials and Methods

Most of the investigations reported in this paper are based on the results of crosses made among seven potato clones—B24-58, Katahdin, Canoga, Earlaine, Houma, 9V224-3 and 9V21-11. These particular clones were selected because they seemed to be representative of the wide variation of male and female fertility found in potato clones used for breeding purposes. All of these except the male-sterile Houma produce varying amounts of viable pollen.

All crosses were made during the early spring months in the greenhouse using plants grown in soil beds or in twelve-inch clay pots. Plants were trimmed to two or three branches and kept upright by tying to stakes. The beds and benches were lighted until 10 p.m. each evening so that all plants had at least 16 hours of illumination. Lights were also used on cloudy days.

Since high temperatures are known to reduce the fertility of some potato clones the temperature at the time each cross was made was recorded. Also, during 1952 and 1953 a cylindrical recording thermograph was used to record the temperature throughout the pollinating season. The greenhouse thermostat was set at 65°F. During the night and on cool-cloudy days the temperature remained below 70°F. On sunny days, however, it often rose as high as 80° to 100°F. The amount of heat accumulating each day was calculated as the degree-hours above 70°F. The units for any one day were determined by counting the number of squares (each square being equal to one degree for one hour) below the line made by the stylus of the thermograph and above the 70° line on the thermograph chart.

Flowers were pollinated at three stages of maturity: 1. About 48 hours before the flower opened; 2. About 24 hours before the flower opened; and, 3. Just after the flower had opened. These three stages were designated as "early bud", "late bud", and "open", respectively. The approximate sizes of buds estimated to be at these three stages are shown in figure 1. In addition to the blossom clusters pollinated at these three stages, for which pollinating was done between 6 and 11 a.m., flowers of each cross were pollinated in the evening between 5 and 9 p.m. An

FIGURE 1.—The stages of maturity at which potato flowers and buds were pollinated: Open—just after the flower had opened. Late bud—approximately 24 hours before the flower opened. Early bud—approximately 48 hours before the flower opened.

attempt was made to have the flowers pollinated in the evening at the late bud stage of development, however, since most flowers open in the morning, the buds pollinated during the evening were somewhat more mature than were those listed as at the late bud stage. In 1952 and 1953 from five to eight flowers for each of the three maturity stages of 42 crosses were pollinated. Also from five to eight flowers of each cross were pollinated during the evening. One half of these pollinations, those in which Earlaine, B24-58, and Canoga were the male parents, were repeated in 1954.

In most instances the pollen was transferred directly from the anther to the stigma by means of a scalpel which was sterilized in alcohol after each cross to prevent contamination. In order to save time and obtain a more even distribution of pollen on the stigma for certain experiments in 1954, an oversize ten-penny finishing nail, its head hollowed by drilling with a 3/32 inch bit, was used as a pollinating cup. The shank of the nail acted as a handle and the cup formed by the drilling was of ideal size to fit over the stigma. A scalpel was used to scrape pollen from the anthers into the cup. The point of the nail was used to spread the corolla when buds were pollinated and the pollinating was done by dipping the stigma into the pollen-filled cup. Enough pollen to pollinate from 60 to 100 flowers could be placed in each cup.

Inflorescences were tagged in a way which permitted each flower within the inflorescences to be identified. All seedball clusters were bagged with cloth bags two or three weeks after pollination. Records were kept so that the time when each cross was made, the temperature at which each cross was made and the stage of flower maturity could be determined after seedballs had matured.

Seeds were counted in all seedballs which set in 1952, in three seedballs per cross in 1953 and in two in 1954. Whenever possible in 1953 and 1954 counts were made from the second and third berries on either side of the cluster. All other fruits in the cluster were removed as soon as it could be determined which were going to set. Only plump seeds were included in seed counts.

Most of the data were subjected to an analysis of variance. Statistically significant differences between means were determined by the Student-Neuman-Keuls Multiple Range Test (8).

Experimental Results

STAGE OF FLOWER MATURITY AT TIME OF POLLINATION

Prior to 1952 most flowers used in the breeding program were pollinated before they opened. During 1951 some flowers pollinated after they had opened, set fruit very rapidly. This in addition to supporting observations of East (6) and Henderson and LeClerg (9) led to the carrying out of an experiment designed to show the relationship between fruit set and age of flower at the time of pollinating. The number of fruit set and seeds per seedball from the crosses made during these three years are shown in tables 1 and 2.

An analysis of variance of the 1953 and 1954 data (the 1952 experiment was not set up so that the data could be analyzed) showed that the percentage of fruit set and the number of seeds per seedball were reduced by pollinating 48 hours before the flower opened. The percentage of fruit set did not differ significantly if the pollinating was done the day preceding, the evening preceding, or the day following flower opening, although the number of seeds per seedball were fewer when buds were pollinated 24 hours before the flower opened than they were if pollinating was delayed until after the flower had opened.

An experiment designed to test the range of flower maturity over which pollination can be expected to have a chance to succeed was set up in 1954. On April 10, 14, and 23, flower clusters with buds and flowers at various stages of development were pollinated with pollen-fertile clones used for this study. The date on which the flowers had opened or would open was estimated at the time of pollination. The results for the three pollinating dates are summarized in table 3.

Under the conditions existing in the greenhouse at Ithaca in April, 1954, the percentage of fruit set in relation to flower maturity formed a normal curve with its peak at about the time the flower opened. Crosses made on flowers at the time they opened or one day after they had opened had the best chance to set fruit but some fruit was set by flowers pollinated at maturity levels from two days before they opened until three days after they had opened.

EFFECT OF TEMPERATURE ON POLLINATION

Although the greenhouse temperature at night and on cloudy days was controlled at 65°F., it rose considerably above that point on sunny days. Since fruit set seemed to be better on some days than on others, even when the clones were crossed, it appeared possible that temperature fluctuations might be influencing fruit set.

As was mentioned previously the heat units above 70° accumulating each day were determined from thermograph charts. Since a record was kept of the date when each flower was pollinated, the percentage of successful crosses under any particular set of temperature conditions was easily determined.

The percentage of fruit set failed to show any correlation with the heat units for any one of the three 24-hour periods just before pollination or for either of the two 24-hour periods immediately following pollination. Partly because Clarke(2) had stressed the importance of temperature

TABLE 1.—*Number of pollinations and number of fruit set from crosses among seven potato clones pollinated at different stages of flower maturity and times of day during 1952, 1953, and 1954.*

Pollinated Year	From 6 to 11 a. m.						From 5 to 9 p. m.				
	Early Bud		Late Bud		Open		Late Bud		Total		
	Flowers Pollinated	Fruit Set	Flowers Pollinated	Fruit Set	Flowers Pollinated	Fruit Set	Flowers Pollinated	Fruit Set	Flowers Pollinated	Fruit Set	
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	Pct.
1952	115	6	270	114	131	71	193	97	709	288	40.6
1953	232	87	347	167	347	191	351	172	1388	617	45.1
1954	113	21	116	59	119	65	111	32	459	188	41.0
Total	460	114	733	340	597	327	655	301	2556	1093	42.8
Set Per cent	20.0		46.5		54.8		47.6				

TABLE 2.—*Seeds per seedball produced from crosses among seven potato clones pollinated at different stages of flower maturity and times of day during 1952, 1953, 1954.*

Pollinated Year	From 6 to 11 a. m.						From 5 to 9 p. m.			
	Early Bud		Late Bud		Open		Late Bud		Total	
	Fruit Counted	Seeds per Fruit	Fruit Counted	Seeds per Fruit	Fruit Counted	Seeds per Fruit	Fruit Counted	Seeds per Fruit	Fruit Counted	Seeds per Fruit
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
1952	3	55	112	108	75	117	91	120	281	114
1953	47	76	84	105	86	146	86	137	303	122
1954	13	75	30	107	30	140	20	134	93	119
Total	63		226		191		197		677	118
Average		75		107		134		129		

TABLE 3.—*Relationship of fruit set to stage of flower maturity at the time of pollination.*

Stage of Maturity	Flowers Pollinated	Fruit Set	Fruit Set
	No.	No.	Per cent
Open 3 days	42	8	19.0
Open 2 days	89	26	29.2
Open 1 day	109	47	43.1
Just opened	125	51	40.8
Late bud	104	34	32.7
Early bud	76	12	17.1
Three days before opening	23	0	0
Total	568	178	31.3

during the time immediately following pollination, the heat units accumulating over the period from 24 hours preceding to 96 hours following pollination were compared with the percentage of fruit set. These data showed a significant negative correlation (r equalled –.88) between fruit set and degree hours for the early bud stage, but no correlation for the other stages of flower development.

Since the period of time from 24 hours preceding, to 96 hours following pollination at the early bud stage, is the same as the period of time from 72 hours preceding to 48 hours following flower opening at that stage, it seemed possible that the reduction in fruit set might be brought about by high temperature at the time of flower opening rather than at the time of pollination. Table 4 shows this relationship for the four stages of flower maturity.

TABLE 4.—*Percentage of fruit set for flowers pollinated in 1952 and 1953 in relation to the cumulative degree-hours above 70°F. for a period of time from 72 hours before to 48 hours after pollination.*

5-day Cumulative Degree-Hours	Stage or Time of Pollination				Total		
	Early Bud	Late Bud	Open	Evening	Flowers Pollinated	Fruit Set	
	Pct. Set	Pct. Set	Pct. Set	Pct. Set	No.	No.	Pct.
20-60	43	63	89	73	323	316	67
61-100	30	59	72	66	589	356	60
101-140	31	40	71	49	343	163	48
Above 140	5	44	45	43	401	123	31
Average	22	53	69	60	1656	858	52

Here the trend was consistent for all four stages. Whenever more degree-hours accumulated, the percentage of fruit set decreased. The percentage of successful pollinations was just half as great when 140 or more degree hours above 70° accumulated during the period of time from 72 hours before to 48 hours after pollination as it was when only 20 to 60 hours accumulated during that period. A series of charts set up to show the relationship between fruit set and degree-hours for each of the five 24-hour periods included in the period of time from 72 hours before

to 48 hours after flower opening disclosed that the degree-hours on any one day did not have any apreciable effect on the amount of fruit set.

The temperature recorded at the hour nearest the time when each cross was made varied from 64° to 76°F. in 1952 and 1953, but, the percentage of fruit set was about the same for crosses made at one temperature within this range as for those made at another. Also a number of crosses were made on afternoons when the thermometer registered above 90°F. Although no counts were made, it appeared that the percentage of fruit set and the number of seeds per fruit were about as good for these crosses as they were for flowers pollinated when temperatures were cooler.

TIME ELAPSE BETWEEN POLLINATION AND POLLEN GERMINATION

In 1954, the number of pollen tubes in styles of flowers pollinated at three maturity stages was determined for four crosses. For each stage of each cross, styles which had been pollinated 24, 36, 48, 60, 72 and 96 hours were flattened onto slides for the counts. The fixing, staining, and slide preparation were a modification of the methods described by Buchholz (1). Only pollen tubes which had germinated but which had not yet reached the ovules could be counted. The average number of pollen tubes in styles of four crosses for each stage at each time are presented in table 5.

TABLE 5.—*The average number of pollen tubes in eight or more styles of potato flowers pollinated at three flower maturity stages and harvested 24, 36, 48, 60, and 72-96 hours after pollination*

Stage	Hours after Pollination and Average Number of Pollen Tubes				
	24	36	48	60	72-96
	No.	No.	No.	No.	No.
Early Bud ..	6.2	7.2	10.0	30.5	52.0
Late Bud	40.0	48.0	69.6	142.4	105.2
Open	110.8	158.8	123.2	173.2	157.2

For flowers pollinated at the early bud stage, the number of tubes found in the style did not increase significantly until after 48 hours following pollination. For flowers pollinated at the late bud stage there was no significant increase of pollen tubes in the styles which were examined until after 48 hours following pollination, but more tubes at 60 hours than at 48 and fewer at 72-96 hours than at 60 were observed. The data available did not show significant differences in total tubes at any time from 24 to 72-96 hours after pollination for flowers pollinated after they had opened.

It is also noteworthy that there were always fewer pollen tubes in the styles of early bud crosses than there were in styles of flowers pollinated at the late bud or open stages of maturity.

DISCUSSION

Fruit set was reduced whenever buds were pollinated earlier than 24 hours before they would have opened. Also few pollen tubes were found in the style before the flower opened no matter how long it had been

pollinated. It is probable, therefore, that with the conditions under which this experiment was carried out most pollen grains germinate after the flower opens no matter at what stage of maturity it is pollinated.

Fruit set was not noticeably reduced by high temperatures on any one day, but it was reduced when high temperatures persisted for several days preceding and following flower opening. The reduction of pollen viability by persistent high temperature has received considerable attention in the past (7, 9). It is of interest that in this study the temperature effect seemed to be more closely correlated with the time of flower opening than with time of pollination. It is apparent that the pistil rather than the pollen was being affected by the high temperature. This suggests that in future studies relating to this subject it would be well to consider the effect of temperature on both the male and the female flower parts.

In addition to the experiments reported in detail in this paper, data were collected which demonstrated that the percentage of fruit set was about the same for flowers pollinated at 6, 7, 8, 9, 10, or 11 a.m. and that the position of a flower within the blossom cluster (*i.e.*, whether it was first, second, *etc.*, to open) made little difference on that flower's chance of setting fruit. Also, pollinating during the evening was as successful as pollinating during the morning hours. Apparently, the potato breeder has considerable choice as to when and how his pollinating is to be done.

Some controversy exists among breeders as to whether or not it is necessary to emasculate flowers used in a greenhouse potato breeding program. Experiments conducted in conjunction with this study showed that, where plants were not shaken during the time they were in bloom, self-pollination of unemasculated flowers was negligible. Whether or not it is necessary to emasculate and/or isolate will depend on local conditions. At Ithaca, New York, for instance, it was difficult to scrape pollen from anthers sooner than 48 hours after the flowers opened. At Aberdeen, Idaho, with the same potato clones in 1957 copious amounts of pollen could be shaken from anthers of flowers which had been open for only 24 hours. At Ithaca bees were seldom found in the greenhouse before late April. At Aberdeen large numbers entered the greenhouse through any available crack during a few sunny days in early March.

The use of the hollow nail insures that the stigma receives as much pollen as it will hold which would be of value in crosses where fruit does not set readily. The nail is of greatest value where a number of flowers are to be pollinated with the same pollen. For our purposes pollen was scraped from the anthers with a scalpel, but the pollinating process could undoubtedly be speeded by using an electric vibrator to collect pollen into a small container or by drying the anthers to aid in releasing the pollen, (10).

Summary

1. Some fruit was set by potato flowers which were pollinated at maturity stages from two days before they opened, to three days after the day on which they opened although the percentage of fruit set was highest for flowers pollinated the day on which they opened, or the day after they had opened. More seeds per fruit were developed from flowers pollinated just after they had opened than from those pollinated 24 hours

before they had opened and these latter, in turn, produced more seeds per seedball than did those pollinated 48 hours before they opened.

2. High temperature, measured in degree-hours above 70°F., for a period from 48 hours before the flower opened until 72 hours after it had opened, caused a greater reduction in fruit set than did high temperature on any one day. This heat effect seemed to be more closely associated with flower maturity than with time of pollination.

3. Most pollen grains on stigmas of clones examined in this study seemed to germinate after the time that the flower would normally open regardless of the stage of maturity at which the flower was pollinated.

4. The position of the flower within the cluster and the morning hour at which the flower was pollinated seemed to have little effect on the chances of that flowers setting fruit. The percentage of fruit set was as high for flowers pollinated in the evening as for those pollinated in the morning.

Literature Cited

1. Buchholz, J. T. 1931. The dissection, staining, and mounting of styles in the study of pollen-tube distribution. Stain Tech. 6: 13-24.
2. Clarke, A. E. 1940. Fertilization and early embryo development in the potato. Amer. Potato Jour. 17: 20-25.
3. ———— and P. M. Lombard. 1939. Relation of length of day to flower and seed production in potato varieties. Amer. Potato Jour. 16: 236-244.
4. ———— and P. M. Lombard. 1942. Flower bud formation in the potato plant as influenced by variety, size of seed-piece, and light. Amer. Potato Jour. 19: 97-105.
5. Driver, C. M. and J. G. Hawes. 1943. Photoperiodism in the potato. Imp. Bur. of Plant Breed. and Genetics. Dec. 1943: 36.
6. East, E. M. 1908. Techniques of hybridizing the potato. Amer. Soc. Hort. Sci. Proc. 5: 35-40.
7. Edmundson, W. C. 1942. Comparison of Katahdin potato pollen produced in the field and in the greenhouse. Amer. Potato Jour. 19: 12-15.
8. Federer, W. T. 1955. Experimental Design. The MacMillan Co., New York, 591 Pp.
9. Henderson, M. T. and F. L. LeClerg. 1943. Studies on some factors affecting fruit setting in *S. tuberosum* in the field in Louisiana. Jour. Agr. Res. 66: 67-76.
10. King, J. R. 1955. Pollen and pollination studies on Irish Potatoes. Amer. Potato Jour. 37: 7-14.
11. Longley, A. E. and C. F. Clark. 1930. Chromosome behavior and pollen production in the potato. Jour. Agr. Res. 41: 867-888.
12. Salaman, R. M. 1926. Potato varieties. Cambridge Univ. Pres, 378 Pp.
13. Werner, H. O. 1941. Effect on berry production of varied day length during the life of two Triumph potato strains. Amer. Potato Jour. 18: 174-178.
14. Young, W. J. 1923. The formation and degeneration of germ cells in the potato. Amer. Jour. Bot. 10: 326-335.

Acknowlegment

The writer wishes to express his appreciation to Dr. J. R. Livermore for guidance which he provided during the time when the research for this paper was being conducted and to the members of the University of Idaho College of Agriculture faculty and others who reviewed the manuscript and suggested ways of improving it.

THE INFLUENCE OF FERTILIZER TREATMENTS ON THE YIELD, GRADE, AND SPECIFIC GRAVITY OF POTATOES IN EASTERN OREGON[1]

JOHN A. YUNGEN, ALBERT S. HUNTER, AND TURNER H. BOND[2]

Approximately 10,000 acres of potatoes are produced each year on the Owyhee and Vale Irrigation Projects and contiguous irrigated lands in Malheur County, in extreme eastern Oregon. Russet Burbank, White Rose, and Bliss Triumph are the principal varieties. Most of these potatoes are harvested in July and August, while still somewhat immature, for immediate marketing. Prior to World War II, commercial fertilizers were seldom employed on the soils of the area, reliance for fertilizer maintenance being placed on alfalfa in crop rotations. Most potatoes are still grown on lands one or two years after alfalfa, but in recent years fertilizer use has become fairly general in potato farming, as well as in the production of most other cultivated row crops in the area.

The effects of fertilizers on the yield, grade, and specific gravity of potatoes were investigated in 17 experiments on 16 farms in Malheur County during the 4-year period, 1950-1953. The experiments were part of an extensive soil fertility research program initiated in 1950 to determine the general fertility status of the soils of the area, the fertilizer needs of the major crops, the effects of fertilizers on crop quality, and the correlations between soil test values and crop yield responses to fertilizers. The effects of fertilizers on the yield and sugar content of sugar beets, and the yield and protein content of corn, determined in experiments conducted in the same area concurrently with those on potatoes, and findings concerning the P and K fertility status of soils of Malheur County, have been reported elsewhere (5, 6, 7). Prior to the initiation of this soil fertility research program very little research had been done on the fertilizer needs of crops on the irrigated soils of eastern Oregon.

MATERIALS AND METHODS

The experiment sites were widely scattered over the approximately 150,000 acres of irrigated lands of the two projects and adjoining area. All the experiments except one, on the Malheur Experimental Area, were on the fields of farmers, who prepared seedbeds, planted, cultivated, and irrigated the potatoes according to their own schedules. A 2-row belt-type fertilizer applicator (4) with one disk and one spear-point furrow opener per row was employed to place two bands of fertilizer beside each row; one band was at about seed-piece level, the other about 1½ inches below the seedpiece, and both were approximately 4 inches from the row.

[1]Accepted for publication July 10, 1957.
Technical Paper No. 1048, Ore. Agr. Exp. Sta. Contribution of the Department of Soils, Oregon Agricultural Experiment Station, Western Soil and Water Management Section, SWC, ARS, USDA, Oregon Agricultural Extension Service, and Oregon Potato Commission cooperating.

[2]Formerly Research Assistant, Malheur Experiment Area, Ontario, Oregon; now Agronomist, South Oregon Branch Experiment Station, Medford, Oregon. Senior Soil Scientist, OAES and WSWMS, cooperatively, Corvallis, Oregon; now Professor of Soil Technology, Pennsylvania State University, University Park, Pa. and Agricultural Extension Agent, Oregon Agricultural Extension Service and Oregon Potato Commission, cooperatively, Ontario, Ore.

Applications were usually made on the day of planting and in all cases within four days of planting. Farmers were careful to apply no fertilizers to the experiment sites during the year of the experiment.

Immediately prior to fertilizer application, soil samples were taken from the 0-8, and 8-16 inch depths, in each replication, or block, of each experiment site. These samples were analyzed for sodium bicarbonate-soluble P (8), exchangeable K and certain other characteristics. The samples of the first two years were analyzed for nitrifiable nitrogen (3).

All soils are irrigated desert soils; textures range from very fine sandy loam to silty clay loam, with silt loams predominating. A soil survey of the area has not been made. The experiment sites were examined by Willis J. Leighty of the Division of Soil Survey, Soil Conservation Service and classified as to type and tentative series.

In several of the experiments soil moisture measurements were made by means of Bouyoucos and Mick electrical resistance blocks (1). In general, moisture tensions did not rise sufficiently to produce significant fluctuations in block resistances. On most farms irrigation water was applied at intervals of 4 to 7 days during the growing season after tubers had set on the plants. Irrigation was not considered limiting in these experiments.

Plots were either 40 feet long and 6 rows wide or 60 feet long and 4 rows wide. Row spacings varied from 34 to 38 inches, with 36-inch spacing being most common. A few days prior to harvest, the green vines of the potatoes (except on 4 farms, harvested in October) were shredded with a rotary beater. At harvest the potatoes from 30 feet of the four central rows or 50 feet of the two central rows were dug by machine by the farmer, picked up in bags by farm picking crews under supervision of the authors, and weighed. Potato farming equipment in the area is designed for two rows. Harvesting of the plots for yield determination was facilitated by superimposing the fertilizer treatments upon the rows in such a manner that the outside rows of 2 contiguous plots were dug together by the farmers' 2-row diggers, leaving the 2, or 4, yield rows in the central portion of the plots to be dug in pairs in one, or two, passes across the field. Samples of approximately 60 pounds from each plot were graded as No. 1, No. 2, and Culls, according to USDA standards. Specific gravity determinations were made on approximately 10 pound samples of the No. 1 potatoes (by use of brine solutions in 1950 and 1951 and by weighing in air and water in 1952 and 1953). All yield and specific gravity data were subjected to analysis of variance.*

The number of experiments completed each year was as follows: 1950, 1; 1951, 6; 1952, 7; and 1953, 3. Table 1 lists the farmers, soil types, previous cropping histories, and values for sodium bicarbonate-soluble phosphorus in the soils of the experiment sites. The varieties of potatoes that were grown in the experiments, and the planting and harvesting data, are set forth in table 2.

In 15 of the 17 experiments rates of 0, 50, 100, and 150 pounds N and 0, 22, and 44 pounds P (0, 50, 100 pounds P_2O_5) per acre were factorially combined, resulting in 12 fertilizer treatments; in addition, there were two, or four, treatments in which 42 or 83 pounds K (50 or 100 pounds K_2O)

*By Jerome C. R. Li, Associate Professor of Mathematics or by Lyle D. Calvin, Experiment Station Statistician.

TABLE 1.—*Soil series and types, previous cropping histories, and sodium bicarbonate-soluble P in soils of potato experiments.*

Farm	Year	Soil Series and Type	Previous Cropping History*	$NaH-CO_3$-Soluble P, Ppm	
				0-8 in.	8-16 in.
Trenkel	1950	Greenleaf 1	B,P,B,P,A	48	28
Gribben	1951	Greenleaf si 1	A,A,A,G,P	5	3
Hart	1951	Series "A" 1**	Cl,G,B,B,P	13	8
Judd	1951	Series "B" vfsl**	A,A,A,G,C	7	4
Maag	1951	Wingville si c l	A,A,A,G,B	14	7
Price	1951	Nyssa vfsl	A,A,A	3	2
Trenkel	1951	Greenleaf 1	Cl,G	15	6
Amick	1952	Series "A" si 1**	Cl,Cl,G	7	7
Deseret	1952	Greenleaf 1	A,A,A,G	6	4
Flanagan	1952	Owyhee si 1	P,A,A,B	15	9
Ireland	1952	Owyhee vfsl	G,A,A,A	10	6
Palmer	1952	Elijah si 1	C,A,A	10	5
Russell	1952	Series "C" vfsl**	P,A,A,A	10	7
Winn	1952	Chilcott si 1	A,A,A,A	7	5
Clausen	1953	Not identified	A,A	9	5
Sitton	1953	Not identified	A,A,A,A,A	5	3
Malheur Station	1953	Owyhee si 1	G,G,B	Not determined	

*Beginning with year previous to potatoes. A=Alfalfa; B=Sugar beets; C=Corn; Cl=Clover; G=Small grain; P=Potatoes.

**Series not correlated.

TABLE 2.—*Potato varieties and planting and harvesting dates of experiments*

Farm	Year	Variety	Date of	
			Planting	Harvest
Trenkel	1950	White Rose	4/21	8/21
Gribben	1951	Bliss Triumph	4/12	8/29
Hart	1951	Russet	5/28	10/11
Judd	1951	Russet	4/6	8/20
Maag	1951	Russet	5/18	10/17
Price	1951	Russet	3/27	8/10
Trenkel	1951	White Rose	4/13	8/13
Amick	1952	Russet	6/9	10/13
Deseret	1952	Bliss Triumph	4/5	7/15
Flanagan	1952	White Rose	4/11	8/4
Ireland	1952	Russet	4/12	8/13
Palmer	1952	Russet	5/23	10/18
Russell	1952	White Rose	4/8	8/5
Winn	1952	Russet	4/30	8/22
Clausen	1953	Russet	3/23	8/25
Sitton	1953	Russet	4/15	10/1
Malheur	1953	Russet	4/17	8/15

were combined with quantities of nitrogen and phosphorus considered adequate for near-maximum yields (50 to 200 pounds N and 44 pounds P per acre). In one experiment (Trenkel 1951) rates of 0, 50, 100 and 200 pounds N and O, 44, 88, and 176 pounds P (0, 100, 200 and 400 pounds P_2O_5) per acre were factorially combined. In an experiment

(Malheur Experiment Area) designed specifically for study of the effects of variations in level of nitrogen on the specific gravity of potatoes, rates of 0, 100, 150 and 200 pounds N and 18 pounds P (40 pounds P_2O_5) were employed. All treatments were replicated four times in 1950, 1951, and 1953, and three times in 1952, in randomized block designs. Ammonium sulfate, concentrated superphosphate, and potassium chloride were employed as sources of nutrients in all experiments.

Results and Discussions

By far the greater part of the cash return to farmers from potato crops in Oregon is from that portion grading U. S. No. 1. A much smaller part is from the portion grading U. S. No. 2. Cull potatoes are ordinarily of very little value. The effects of fertilizers on the yields on No. 1 potatoes are therefore of much more importance than their effects on total yields or yields of No. 2 and cull potatoes.

In the present experiments the principal fertilizer responses of potatoes were to nitrogen. The effects of nitrogen on the yields of No. 1, No. 2, and total potatoes in 16 experiments are summarized in table 3 (in one experiment the potatoes were not graded.) The data are grouped according to effects on yields of No. 1 potatoes.

The yields of No. 1 potatoes were increased by nitrogen on 8 farms, decreased on 2 farms, and not significantly affected on 6 farms.

There was no clear relationship between yield responses to nitrogen fertilizer and previous cropping with leguminous or non-leguminous crops or soil series and type. Of the eight farms on which significant increases in yields of No. 1 potatoes were obtained, five had alfalfa; one had clover; one had small grain; and one had potatoes as the previous crop. On the two farms on which significant decreases in No. 1 potatoes resulted from nitrogen, the previous crops were sugar beets and red clover, respectively. Of six farms on which nitrogen effects on yields were not significant, three had alfalfa and one each had clover, corn, and potatoes as the preceding crop.

Outstanding increases in No. 1 potato yields were produced by nitrogen on the Gribben, Judd, and Ireland farms, despite the fact that on the first two of these farms potatoes followed three years of alfalfa and it was the second crop following two years of alfalfa on the latter. The recency of a legume in the cropping sequence is not an infallible index to the needs for nitrogen fertilizer. In some cases the residue from an alfalfa stand several years old does not provide enough nitrogen for maximum production.

Attempts were made to relate responses to nitrogen fertilizer to the amounts of nitrate nitrogen in soil samples after three weeks incubation at 25 per cent moisture content and 35°C. The attempts were unsuccessful, owing in part, no doubt, to the inherent difficulties of adequately sampling soils containing freshly plowed-down legume roots and stems and estimating in the laboratory their contribution to the soil nitrogen supply during the cropping season.

Of the eight farms where increased yields of No. 1 potatoes were obtained, in no case was the yield increased significantly by rates of nitrogen greater than 100 pounds N per acre. On four farms yields were

TABLE 3.—*Summary of effects of nitrogen fertilizer on yields of potatoes in experiments on 16 farms.*

Farm	Year	No. 1 Potatoes Rate of N, Lbs/A.					No. 2 Potatoes Rate of N, Lbs/A.					Total Potatoes Rate of N, Lbs/A.				
		0	50	100	150	LSD*	0	50	100	150	LSD*	0	50	100	150	LSD*
		Yields in Hundred-weights Per acre														
		Farms on Which N Significantly Increased Yields of No. 1 Potatoes														
Gribben	1951	243	333	348	339	30	28	30	34	31	N.S.	318	406	423	411	27
Judd	1951	99	146	205	203	31	25	44	46	55	16	180	254	302	312	26
Trenkel	1951	282	292	306	273	23	28	31	34	43	10	374	390	395	390	N.S.
Deseret	1952	223	249	236	244	15	12	21	24	22	5	260	293	285	280	15
Ireland	1952	129	269	313	323	29	15	42	63	76	18	161	328	400	428	24
Russell	1952	226	285	280	283	28	39	52	53	53	N.S.	292	362	360	363	23
Clausen	1953	162	187	215	213	28	44	71	85	76	N.S.	258	322	352	348	41
Sitton	1953	57	70	96	85	23	27	39	45	44	N.S.	170	189	232	221	36
Mean		178	229	250	245		27	41	48	50		252	318	344	344	
		Farms on Which the Effects of N on the Yields of No. 1 Potatoes Were Not Significant														
Maag	1951	68	69	63	47	N.S.	121	141	133	146	N.S.	220	266	239	242	N.S.
Price	1951	76	67	82	81	N.S.	34	44	39	49	N.S.	176	189	206	214	N.S.
Amick	1952	122	152	167	160	N.S.	10	19	35	41	9	209	249	274	271	33
Flanagan	1952	277	272	262	245	N.S.	38	56	48	50	N.S.	341	359	341	326	16
Palmer	1952	112	131	131	111	N.S.	72	83	94	102	N.S.	231	267	280	269	N.S.
Winn	1952	104	108	106	95	N.S.	32	55	52	63	17	153	180	174	181	N.S.
Mean		127	133	135	123		51	66	67	75		222	252	252	251	
		Farms on Which N Significantly Decreased Yields of No. 1 Potatoes														
Trenkel	1950	226	198	197	166	32	79	105	100	119	29	346	344	339	326	N.S.
Hart	1951	285	283	260	247	31	72	81	107	121	26	384	394	395	398	N.S.
Mean		255	240	228	206		75	93	103	120		365	369	367	362	
Grand Mean		168	194	204	195		42	57	62	68		255	300	312	311	

*Least significant difference, at P = 0.05.

not increased significantly by rates above 50 pounds N per acre. The relatively large increases in yields (90, 47, 140, and 61 cwt. per acre on the Gribben, Judd, Ireland, and Russell farms, respectively) resulting from the first 50 pound increment of nitrogen and the failure to increase yields significantly with more than 100 pounds, are considered evidence that 50 to 100 pounds N per acre are probably adequate for potatoes on most soils of the area.

On soils in which the supply of nitrogen is already high, the application of more nitrogen may result in rough or knobby potatoes, particularly in cases where soil moisture is allowed to fall to low levels before irrigation. The tendency towards increased roughness and higher percentages of No. 2 grade at higher levels of nitrogen is more pronounced in long potatoes such as Russet Burbank or White Rose than in round varieties such as Bliss Triumph. The application of nitrogen fertilizer to a soil already high in nitrogen may decrease the percentage of No. 1 potatoes and increase the percentage of No. 2 potatoes without having significant effects on the total yield. This was apparently the case on the Trenkel (1950) farm, to which heavy applications of fertilizers and manure had been made to previous crops, and also on the Hart farm, where a rank growth of red clover was plowed under in May, shortly before planting of the potatoes. Increasing applications of nitrogen also increased the percentage of No. 2 potatoes on the Amick and Winn farms, on which yields of No. 1 potatoes were not significantly affected.

The effects of nitrogen on specific gravity of potatoes were measured on 14 farms. On 10 farms nitrogen effects on specific gravity were statistically significant; the specific gravity decreased with increasing nitrogen fertilizer. This is thought to be related to the degree of maturity at harvest. In general, at harvest the vines on early-harvested potatoes were greenest in color on the plots of highest nitrogen rates, indicating least maturity; on late-harvested potatoes the vines on high nitrogen plots remained green longest. Although variations in specific gravity were statistically significant in several cases, they were of little practical consequence, practically all the values being within the range for satisfactory quality for baking. A summary of the specific gravities of the potatoes in these experiments is given in table 4. The average specific gravities were all within the range from 1.070 to 1.105, and most of them were greater than 1.080.

On 12 farms the effects of phosphorus on yields were not significant. The yields of No. 1 potatoes were increased by phosphorus on the Gribben, Deseret, and Sitton farms. The total yields of the crop were increased on these three and the Price farm, as shown in table 5. Values for sodium bicarbonate-soluble phosphorus were lower for the soils of these four farms than for others of the 16 on which phosphorus was a variable. Olsen *et al.* (8) estimated that responses, probable responses, and unlikely response to phosphorus may be expected when soil test values for sodium bicarbonate-soluble phosphorus are equivalent to 0 to 5.5, 5.5 to 11, and above 11 parts per million, respectively. The data from these experiments indicate that their estimations are reasonable for potatoes on the soils of Malheur County. On 13 farms effects of phosphorus on specific gravity were not significant. On three farms (Ireland, Amick and Hart) increasing rates of phosphorus increased the specific gravity of the potatoes. However,

TABLE 4.—*Summary of effects on nitrogen fertilizers* on specific gravity of potatoes.*

Farm	Year	Rate of N, lbs/A. 0	50	100	150	LSD**
Farms on Which N Significantly Increased Yields of No. 1 Potatoes						
Gribben	1951	1.089	1.088	1.088	1.088	N.S.
Judd	1951	1.101	1.102	1.101	1.098	N.S.
Trenkel	1951	1.104	1.097	1.091	1.084	0.006
Deseret	1952	1.079	1.074	1.072	1.071	0.003
Ireland	1952	1.091	1.093	1.093	1.089	0.002
Russell	1952	1.086	1.086	1.080	1.077	0.004
Clausen	1953	1.105	1.103	1.100	1.099	0.003
Sitton	1953	1.091	1.089	1.090	1.089	N.S.
Mean		1.094	1.092	1.089	1.087	
Farms on Which the Effects of N on the Yields of No. 1 Potatoes Were Not Significant						
Maag	1951	1.085	1.086	1.083	1.082	0.003
Amick	1952	1.086	1.085	1.084	1.082	0.002
Flanagan	1952	1.085	1.078	1.072	1.070	0.005
Palmer	1952	1.089	1.089	1.088	1.086	N.S.
Mean		1.086	1.085	1.082	1.080	
Farms on Which N Significantly Decreased Yields of No. 1 Potatoes						
Trunkel	1950	1.102	1.095	1.087	1.081	0.006
Hart	1951	1.091	1.086	1.086	1.081	0.003
Mean		1.096	1.090	1.086	1.081	
Grand Mean		1.092	1.089	1.087	1.084	

*In combination with O, 22 and 44 lbs. P per acre (except Trunkel 1951, where rates of P were O, 22, 44, 88, and 176 lbs. per acre.)

**Least significant difference, at P = 0.05.

TABLE 5.—*Summary of effects of phosphorus fertilizer on yields of potatoes on 4 farms where phosphorus increased yields.*

Farm	Yields in Hundredweights per Acre											
	No. 1 Potatoes Rate of P, Lbs/A.				No. 2 Potatoes Rate of P, Lbs/A.				Total Potatoes Rate of P, Lbs/A.			
	0	22	44	LSD*	0	22	44	LSD*	0	22	44	LSD*
Gribben	293	317	337	26	34	32	26	N.S.	365	396	406	24
Deseret	222	241	244	17	17	21	21	N.S.	262	284	292	17
Sitton	65	91	75	20	31	38	44	N.S.	174	208	212	31
Price	78	66	87	N.S.	41	39	44	N.S.	186	183	219	31
Mean	165	179	186		31	33	34		247	268	282	

*Least significant difference, at P = 0.05.

the increases in specific gravity were only barely significant statistically, and of no practical consequence, the greatest increase being 0.003.

No significant effects were observed from the use of potassium fertilizers in these experiments. Applications of potassium did not significantly affect yields or specific gravities, nor the appearance of the

potatoes. In some experiments (2) it has been found that potassium fertilizers, specially the chloride form, may cause marked reductions in specific gravity. Malheur County soils have been found, in general, to contain relatively large quantities of exchangeable potassium (7), of the order of 1 milliequivalent per 100 grams, which is equivalent to 782 pounds K per 2 million pounds soil. Exchangeable potassium in the upper 24 inches of soil is of the order of 1900 to 3300 pounds K per acre.

Observations indicated that differences in specific gravity of potatoes were related to differences in degree of maturity. All plots of any given experiment were of necessity harvested on the same day; on some plots, treated with high rates of nitrogen, the potato vines were greener than those on the check or low nitrogen plots. In order to study changes in specific gravity with time, as potatoes grown with variable rates of nitrogen approached maturity, an experiment was established for that purpose in 1953. Russet potatoes were planted on April 18. Nitrogen was applied at rates of 0, 50, 100, 150 and 200 pounds N per acre. Beginning July 9 and continuing at frequent intervals until September 15, samples of potatoes (8 to 10 pounds) were harvested from each plot and tested for average specific gravity. Except for the July 9 sampling, the specific gravity determinations were made on potatoes of at least minimum commercial size (2 in. diameter or 4 oz. weight).

Changes in specific gravity with time, as affected by rate of nitrogen fertilizer, are shown in figure 1. At all rates of nitrogen specific gravity increased progressively as the potatoes approached maturity, nearly to the final sampling date, when the potatoes of the 0 and 50 pounds N treatments were practically mature. Throughout most of the season the specific gravity values were in similar order and inversely related to the rates of nitrogen applied. The application of analysis of variance and the multiple range test

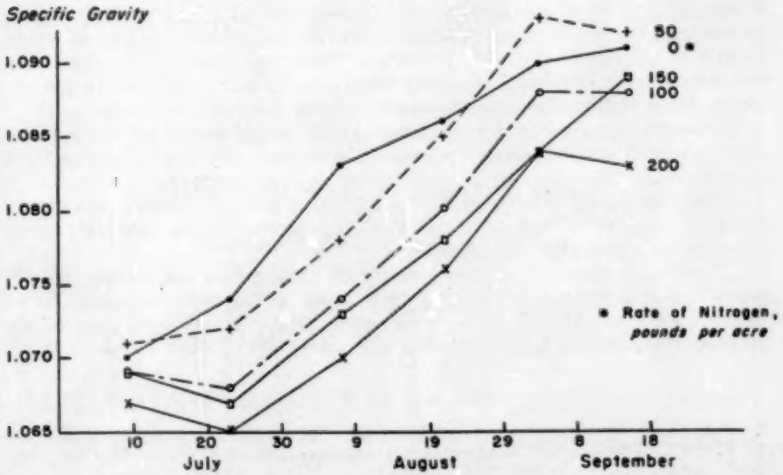


FIGURE 1.—The specific gravity of Russet potatoes as affected by time and rate of nitrogen fertilizer, Malheur Experimental Area, 1953.

to the data indicated that throughout the sampling period the specific gravities of the potatoes grown with 0 and 50 pounds N per acre were significantly higher than those grown with the three higher rates. On the final sampling date the maximum difference in the specific gravity of the potatoes from the 0 to 150 pounds N treatments was only 0.004. The potatoes from the 200 pound N treatment were significantly lower in specific gravity; they were also least mature, as indicated by greenness of vines.

Summary

The effects of fertilizers on the yield, grade, and specific gravity of potatoes were investigated in 16 experiments on irrigated farms in Malheur County, Oregon. In another experiment the effects of variations in nitrogen on changes in specific gravity of potatoes with time were studied. Major emphasis in the experiments was on nitrogen and phosphorus with lesser emphasis on potassium.

The yields of U. S. No. 1 potatoes were increased by nitrogen on 8 farms, decreased in 2, and not significantly affected on 6 farms. There was no clear relationship between yield responses to nitrogen and previous cropping with legumes or non-legumes, or soil series and type. Large yield increases were obtained from nitrogen on two farms on which potatoes followed three years of alfalfa. Residues from several years of alfalfa do not always provide sufficient nitrogen for high yields of potatoes. In no case was the yield of No. 1 or total potatoes increased significantly by rates greater than 100 pounds N per acre. An application of nitrogen to a soil already adequately supplied may decrease the yield of No. 1, increase the yield of No. 2, and have no significant effects on the total yield of potatoes. This was apparently the case on two farms.

Increased rates of nitrogen produced statistically significant decreases in specific gravity of potatoes from 10 of 14 farms on which specific gravity determinations were made. Variations in specific gravity appeared to be related to degree of maturity at harvest. Although statistically significant, differences were of limited practical consequence, nearly all specific gravity values being within the range for good quality.

Phosphorus increased yields on four farms. The soils of these farms were lower in sodium bicarbonate-soluble phosphorus than those of non-responsive farms.

No significant effects of potassium on yields or specific gravity of potatoes were observed. The soils of the area contain relatively large amounts of exchangeable potassium.

Increased rates of nitrogen fertilizer resulted in decreasing specific gravity of potatoes sampled from early tuber set to near maturity. At all rates of nitrogen, specific gravity increased progressively with time as the potatoes approached maturity.

Literature Cited

1. Bouyoucos, G. J., and A. H. Mick. 1940. An electrical resistance method for the continuous measurement of soil moisture under field conditions. Mich Agr. Exp. Sta. Tech. Bull. 172.
2. Dunn, L. E., and R. E. Nylund. 1945. The influence of fertilizers on the specific gravity of potatoes grown in Minnesota. Amer. Potato Jour. 22: 275-288.

3. Fitts, J. W., W. V. Bartholomew, and H. Heidel. 1953. Correlation between nitrifiable nitrogen and yield response of corn to nitrogen fertilization on Iowa soils. Soil Sci. Soc. Amer. Proc. 17: 119-122.
4. Hunter, A. S. 1951. A versatile fertilizing and seeding machine for experimental plots. Agron. Jour. 11:575-579.
5. ————, and J. A. Yungen. 1952. The responses of sugar beets to fertilizers, spacing, and irrigation on eastern Oregon soils. Amer. Soc. Sugar Beet Technol. Proc. 1952: 180-188.
6. ————, and ————. 1955. The influence of variations in fertility levels upon the yield and protein content of field corn in eastern Oregon. Soil Sci. Soc. Amer. Proc. 19: 214-218.
7. ————, ————, and L. A. Albin. 1957. Two approaches to determination of the fertility status of Malheur County, Oregon soils. Soil Sci. Amer. Proc. 21: 210-215.
8. Olsen, S. R., C. V. Cole, F. S. Watanabe, and L. A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S.D.A. Circ. 939.

When You Buy
Minnesota CERTIFIED Seed Potatoes

You are investing in a commodity produced by a group of growers who understand and know how to meet the many problems involved in growing

HIGH QUALITY SEED STOCK

Certified Seed List sent on request

**STATE OF MINNESOTA
DEPARTMENT OF AGRICULTURE**

SEED POTATO INSPECTION AND CERTIFICATION

St. Paul Campus **University of Minnesota**

St. Paul 1, Minnesota

University Microfilms
313 North 1st St
Ann Arbor Michigan

MAINE CERTIFIED

1st CHOICE FOR

SEED POTATOES

Growers know they can expect good returns when they plant the quality that for more than 40 years has made MAINE a leading source of fine . . .

CERTIFIED SEED

CLEAN — DEPENDABLE — SURE

●

Maine is the nation's "Shopping Center" for Better Seed Potatoes — Twenty-five varieties and various grades.

●

Sized To Meet Your Needs

Regular: 1⅞" - 3¼". (Any closer size within these limits is permitted.)
Sized: 1⅞" - 2½". The most popular size range. Carries blue tag, plus size tag.
Size B: 1½" - 2". Carries green tag.
Small Size: 1½" - 2¼". Carries white tag.

●

The Maine Seed Potato list for 1957 is easy to use. All varieties are listed separately — with cross references to growers with more than one variety.

For Free Copy Write Paul J. Eastman, Chief, Division of Plant Industry,

MAINE DEPARTMENT OF AGRICULTURE

AUGUSTA, MAINE